

In a paper by A. E. M. Geddes, published in the *Quarterly Journal of the Royal Meteorological Society*, April, 1915, volume 41, pp. 123-135, pilot-balloon observations at the Observatory, King's College, Aberdeen, are discussed particularly with reference to wind values aloft in relation to the gradient wind. The rates of ascent of the balloons are given, however, and tabulated according to the kind of cloud in which the balloon was lost.

In the case of strato-cumulus clouds, it is stated that for corresponding lifting powers the upward velocities were greater than on clear days. (Cf. footnote † on p. 223.) No sudden increase, however, was observed on passing into the cloud.

A sudden increase in upward velocity was observed in all cases but one where the balloon passed into cumulus clouds. In one of these flights, the balloon rose at a rate of 6.2 meters per second immediately before passing into the cumulus cloud. This gives a rate of 372 meters per minute, which is not much different from the high rate noted at Fort Monroe on June 13, 1918.

With fracto-cumulus clouds there was a sudden rise at the base of the cloud. This sudden increase was not so large as in the case of cumulus clouds.

With stratus clouds there was a fairly uniform vertical velocity with no remarkable increase on entering the cloud.

In conclusion, it is stated that "in making observations with one theodolite it consequently becomes incumbent on the observer to take note not only of the free lift of his balloon, but also to study the type of cloud into which his balloon is likely to disappear, and the tendency of the

barometer, before assigning any definite vertical velocity. Even then the assumption of a uniform vertical velocity is apt to round off corners and bring the condition of the atmosphere into a more ideal state than it really is. When a considerable altitude is reached, say over 3 kilometers, surface influences will have disappeared, and the one-theodolite method may be superior to the other, seeing that the base is often small compared with the distance the balloon has traveled."

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In many instances there is not any sudden increase in rate of ascent when the balloon passes into cumulus clouds. This does not prove, however, that such vertical movements do not exist. With two theodolites the balloon is often lost at one station two or even five minutes before it is lost in or behind the cloud at the other station. The number of cases in which the balloon actually disappears in the cloud at both stations at the same time is comparatively small. Consequently it may be that in many instances the balloon passes behind the cloud or between two clouds.

In conclusion, it may be said that inasmuch as it is often necessary to observe a balloon with only one theodolite or to continue an observation when the balloon is lost to one observer, it is necessary to make a careful inspection of clouds before concluding that the drift of the balloon as plotted represents the movement of the wind. A considerable departure of the actual from the computed rate will, with one-theodolite observations, produce a serious error in the wind data deduced.

THE WORK OF THE AEROGRAPHIC SECTION OF THE NAVY.¹

By Lieut. Commander ALEXANDER McADIE, U. S. N. R. F., Senior Aerographic Officer.

(Dated: Harvard University, Blue Hill Observatory, Readville, Mass., Mar. 27, 1919.)

Early in January, 1918, the Assistant Secretary of the Navy asked Prof. McAdie to supervise the organization of an aerographic section in the Navy. Enrolling as lieutenant commander in the Reserve Force, this officer reported to Capt. N. E. Irwin, United States Navy, Director Naval Aviation Operations. He sailed for Europe early in April, accompanied by eight aerographic officers to take over certain observations in the British Isles and France.

Instruction in meteorology had been given in a general way at a number of naval air stations, but definite work in aerography,² similar to that carried on at British, French, and Italian air schools, may be said to have had its beginning on December 3, 1917, when the first group of students who had finished the course in the Ground School at the Institute of Technology, reported at Blue Hill Observatory for an intensive course of instruction in aerography. To aid in the rapid establishment of the service, Lieut. W. F. Reed, jr., also gave considerable practical and theoretical instruction at Pelham Bay, N. Y., during January, February, and March, 1918. A knowledge of the structure of the atmosphere, the relation of wind and pressure, the variation of wind with height, eddy motion, turbulence in relation to gustiness, the use of sounding and pilot balloons, forecasting for aviators at foreign and home stations, and some familiarity with the work of modern investigators—Dines, Shaw, Rotch, Gold, Cave, Taylor, and others—were regarded as necessary. As the instrumental equipment of the observatory

includes many European instruments not found elsewhere in this country, students had opportunity to familiarize themselves with such instruments. The work was upon a postgraduate basis and the men entering were required to hold university degrees or possess a training equivalent to that required for a degree at the Massachusetts Institute of Technology. In all 56 men took the course. These (with the exception of four) received their commissions as ensigns. Twenty-eight American universities or colleges were represented. Of the whole number 22 had foreign service.

Through the courtesy of the British Admiralty, officers upon their arrival in Europe were permitted to spend two weeks at selected air stations, and thus get in touch with latest developments.

The British Admiralty also kindly agreed to furnish 20 complete outfits for aerographic observatories (see Fig. 2, opposite p. 227, below).

Many of the officers were elected Fellows of the Royal Meteorological Society and while in London were made welcome at the library and offices of the society. We were also made to feel at home in the Meteorological Office and were allowed the privilege of being in the Forecast Room when work was in progress. It must be remembered that at this time all weather information was confidential. Harmonious relations were maintained with the Air Service of the Army in France. Lieut. Commander McAdie and Maj. Bowie had many conferences at the Bureau Central Météorologique, and received every courtesy from the director, Prof. A. Angot.

By this cooperation, the Navy aerographers on the coasts of Ireland, England, and France became part of

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² "Aerography" as here used is practically synonymous with "meteorology," except that it implies that the main emphasis of the work had to do with free-air conditions.—EDITOR.

the receiving and distributing network of weather-reporting stations. Reports from sea, however, were scant, owing to the ban upon the use of radio.

At each observatory, when in full working order, there were two aerographic officers and six quartermasters, class A, aerographic. Commanding officers could thus call for information and advice at any hour of the day or night. Sondages at some important coast stations were taken every two hours. Many commendatory reports have been made regarding the service in connection with the operation of both lighter-than-air and heavier-than-air machines. Particularly in connection with the successful operation of blimps was the value of wind directions and velocities at different levels apparent. At some stations the number of hours of patrol increased decidedly after the establishment of the aerographic observatory. In addition to surface and flying level winds, the aerographer was expected to forecast visibility and especially advection fogs and sea fogs. Thunderstorms, gustiness, changes in the lapse rate (vertical gradient) of temperature as well as horizontal gradients, heavy rains, likelihood of snow at high levels, frosts, and surface temperature inversions were regarded as subjects bearing directly upon the safety of fliers and therefore to be noted and investigated with all diligence.

At first, American naval aerographers followed rather closely the methods of the British observers in the Hydrographic Department of the Admiralty, but in France they soon discarded the old English units and also modified materially the methods of work. Many good suggestions came from various members both in the field and at home. The two-theodolite method originally used at Blue Hill was soon displaced by the one-theodolite method of following pilot balloons, and while it is fully recognized that this method is open to criticism, it is quick and worked fairly well in actual operation. Several rapid methods of calculation were designed by the officers at Blue Hill. All of these can not be described here, but those of Ensigns Davy, Twitchell, and Mall were successfully tried out. Inasmuch as a short review of some of these methods may be of interest to others working in this field, I append a note by Ensign Mall, which, while not describing his own automatic device, gives briefly the cardinal points of the Davy Rapid Calculator and the Twitchell Vector. An extended paper on the subject has been prepared by Ensign Twitchell, but can not be given here. Ensigns Townshend, Parsons, and Davy designed an automatic balance for use in filling balloons, giving free lift and dead weight. Ensign RuKeyser designed a cage for approximately determining free lift, for use where other methods could not apply.

Some studies of the depth of the sea breeze in the East Gulf were made by Lieut. Reed at the Pensacola station.

During the absence of Prof. McAdie abroad, the following lectured to the classes: Chief Observer L. A. Wells, Ensigns Keyser, Buck, Townshend, Davy, Parsons, Mall, and RuKeyser. Lieut. R. F. Barratt was in charge of foreign stations after the return of the senior aerographic officer to the United States.

Eighteen stations were established in France, six in Ireland, and two in Italy. An account of the equipping and instrumental work in the United States is given in the following note by Commander Jewell.

WORK OF THE NAVAL OBSERVATORY IN CONNECTION WITH NAVAL AEROGRAPHY.

By Commander C. T. JEWELL, U. S. N., Retired.

Communicated by the Superintendent, Naval Observatory, Washington, Mar. 14, 1919.]

The Naval Observatory's proper function in the development of aerography was the procurement and issue of suitable instruments. This was accomplished under the superintendency of Rear Admiral T. B. Howard, U. S. N., retired.

When the policy of establishing naval flying stations at home and abroad was definitely adopted in the summer of 1917, the Observatory, on its own initiative, added to the allowance list an aneroid barometer, a wet-and-dry-bulb psychrometer, and a masthead anemometer, all Navy standard articles of which there was a stock on hand, so that the Air Stations could keep a record of weather conditions commensurate with that kept on board vessels of the Navy.

The following winter it developed that there was need of more extensive equipment. An appeal to the Observatory was made in December, 1917, for pilot balloons and theodolites for air sounding, and in the following summer the Observatory went into the market for a full set of meteorological instruments for air stations in the United States.

A step in advance in the way of cooperation with foreign observers was made at this time by having the charts on which records were kept by recording instruments of various types printed in metric and centigrade scales rather than the usual English units.

Wind vanes were supplied without registers, for visual observation only, as it was early recognized that our business dealt with the upper air currents and not with the surface winds.

An anemometer recording the passage of air equal to a wind movement of 1/60 of a mile had been adopted for naval use before the war. These were issued to Air Stations at home. Air Stations abroad were supplied with instruments obtained abroad without any action on the part of the Observatory.

After supplying instruments recording in metric units, the pressure, temperature, and humidity at the stations on shore, the Observatory turned its attention to wind-measuring instruments. The Draper Instrument Co., of New York, supplied 20 anemoscopes of their design. These instruments show the exact direction of the wind at any moment, giving a record which illustrates the variability of the wind as well as its general direction. For wind pressure and velocity, the department finally adopted a modification of Dine's anemobiograph.

The development of the Aerographic Service at the home stations is practically the work of Ensign E. B. Buck, U. S. N. R. F. First he had charge of the aerographic students at the Blue Hill Observatory; later as an assistant to the Director of Naval Aviation, he advised as to the detail and station of the aerographic officers he had trained, and finally, as an assistant to the superintendent of the Naval Observatory, he handled the minutiae of getting the home stations equipped and operations started. Key West, Miami, Chatham, Halifax, and San Diego were actually at work keeping records and making forecasts at the time the armistice